

February 3, 2012



Honorable Chairman John F. Tavaglione  
and Honorable Members of the  
Riverside County Board of Supervisors  
4080 Lemon Street, 5th Floor  
Riverside, CA 92501

**Re: HEALTH AND ECONOMIC AIR QUALITY IMPACT ANALYSIS FOR THE PROPOSED  
LIBERTY QUARRY**

Honorable Supervisors:

**PCR Services Corporation** (PCR) performed an analysis to determine potential health effects and associated economic impacts due to pollution generated by the Liberty Quarry project.

**EXECUTIVE SUMMARY**

The analysis PCR performed demonstrates that the emission of fine, respirable particulate matter from the operation of the Liberty Quarry will result in quantifiable increases in negative health outcomes for the population of Temecula (approximately 100,000 in Year 2010). Specifically, Temecula residents can expect an increase in acute bronchitis, exacerbation of asthma, emphysema, cardiovascular related issues, lost work and school days. Over the lifetime of the proposed quarry, 145 new cases of acute bronchitis, 49 nonfatal myocardial infarctions (heart attacks), 146 cases of premature mortality, over 2,000 cases of respiratory problems and over 8,000 work-loss days are predicted to occur due to the routine operations of the proposed Liberty Quarry. These health effects will result in economic costs of \$12.8 million per year, and approximately \$957 million to the Temecula Valley over its 75-year permitted lifetime

**BACKGROUND**

In 2009, an Air Quality Impact Analysis (AQIA) was prepared for the Proposed Liberty Quarry project by the project applicant. The AQIA also contained a health risk assessment (HRA) which calculates the increased risk of cancer and other non-cancer health effects due to toxic air contaminant (TAC) emissions from the proposed Liberty Quarry project. A TAC is defined by the State of California Health and Safety Code as “an air pollutant which may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose or present a potential hazard to human health.”<sup>1</sup> Compounds which may be hazardous to human health include those that are carcinogenic, mutagenic, teratogenic, neurotoxic, or cause reproductive dysfunction.

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<sup>1</sup> California Health and Safety Code, Section 39655.



The State of California Air Resources Board (CARB) and the United States Environmental Protection Agency (USEPA) recognize that exposure to elevated levels of criteria pollutants (so-named due to the criteria developed to assess attainment of air quality standards under the Federal Clean Air Act and California Clean Air Act) may also result in negative health consequences. As a basis for developing the PM<sub>2.5</sub> (particulate matter, less than or equal to 2.5 microns in diameter) ambient air quality standard, the USEPA has stated that health studies have shown significant association between exposure to fine particles and premature mortality as well as other respiratory and cardiovascular disease.<sup>2</sup> Although it has been demonstrated that exposure to fine particulates results in adverse health impacts, PM<sub>2.5</sub> is not defined as a TAC. As a result, the final Liberty Quarry Environmental Impact Report (Liberty Quarry EIR) did not include PM<sub>2.5</sub> in the AQIA health risk analysis despite serious health consequences associated with exposure. Furthermore, the Liberty Quarry EIR only calculated the incidence or occurrence of an adverse health impact (cancer, acute and chronic risk) resulting from compounds which have been identified as a TAC, but pollutants such as PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub> or ozone were not evaluated as part of a health risk assessment for the Liberty Quarry EIR. Therefore, the Liberty Quarry EIR only evaluated health impacts (cancer, chronic and acute non-cancer effects) from the narrowly defined TACs, excluding PM<sub>10</sub> and PM<sub>2.5</sub>.

As a result, the Liberty Quarry EIR ignored obvious and prevalent health impacts associated with the severe degradation of the air quality of the surrounding areas. Furthermore, according to the Liberty Quarry EIR, pollutant emissions from the Liberty Quarry project will increase pollutant concentrations from the current baseline level of 40% to be 98% of the health protective standards, more than doubling the current levels. However, this is based upon the Liberty Quarry EIR which underestimates the pollutant concentrations so the increase in pollutant concentrations is much higher than disclosed in the Liberty Quarry EIR. SAGE Environmental Consulting (SAGE) has also recently reviewed the emissions calculations prepared for the Liberty Quarry EIR, and identified sources from which pollutant emissions were greatly underestimated using incorrect factors. SAGE has previously provided oral testimony and submits to the Board its written conclusions under separate cover.<sup>3</sup>

The degradation of air quality estimated to occur with the long-term operation of the Liberty Quarry will have health impacts not only limited to those analyzed as part of the narrowly defined list of TACs, but will also cause additional illnesses not analyzed in the Liberty Quarry EIR. Some of these respiratory illnesses that will be caused by the project include asthma exacerbation, pneumonia, upper and lower respiratory illness, and heart attacks are not

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<sup>2</sup> USEPA PM<sub>2.5</sub> NAAQS Implementation: [http://www.epa.gov/ttnnaqs/pm/pm25\\_index.html](http://www.epa.gov/ttnnaqs/pm/pm25_index.html)

<sup>3</sup> Air Quality Issues Associated with the Appeal of Liberty Quarry Project. SAGE Environmental Consulting. January 30, 2012.



analyzed as part of the Liberty Quarry HRA. Furthermore, the Liberty Quarry EIR limited the study radius to receptors located near the project site.

In the TAC-based Liberty Quarry HRA, health risk values (cancer, chronic and acute) were calculated for the closest sensitive receptors and a few receptors located in the City of Temecula. These values were presented as a single number as the probability that an individual would develop adverse health effects as a result of project TAC emissions. The use of a single number threshold may be representative of the average population (healthy and young), but may not properly take into account sensitive populations such as people who are very young, old or sick. As mentioned previously, criteria pollutants such as PM<sub>10</sub> and PM<sub>2.5</sub> are not considered as a TAC and therefore were not included in the health risk assessment contained in the Liberty Quarry EIR.

Based on the relationship between fine particulate matter exposure and adverse health effects, the City of Temecula has commissioned PCR to perform an assessment of health impacts to residents from criteria pollutant emissions. Although PM<sub>10</sub>, ozone and NO<sub>2</sub> are harmful pollutants, health incidence data for these specific pollutants is limited. Therefore, this report focuses on PM<sub>2.5</sub> generated from project activities including fugitive dust and heavy equipment exhaust. This assessment provides detailed information on the projected number of residents who will be affected by Liberty Quarry pollutant emissions.

#### **AMBIENT CONCENTRATIONS**

Substantial evidence has surfaced through the public comment process demonstrating that emissions of PM<sub>2.5</sub> have been under estimated by the Liberty Quarry applicant. For example, the re-entrainment of roadway dust calculated in the Liberty Quarry EIR was based on a "Freeway Clean" assumption. Regulatory guidance has shown that this value is approximately 100 to 1000 times less than the recommended value, resulting in an underestimation in emissions from the project.<sup>4</sup> In order to properly account for the road dust emissions that were inappropriately calculated in the Liberty Quarry EIR, emissions were recalculated and additional dispersion modeling, using the same USEPA approved AERMOD dispersion model, was performed by SAGE Environmental Consulting. The results of the amended dispersion modeling studies were then provided to PCR<sup>5</sup>. Concentrations were estimated at receptors spaced evenly throughout the City, up to a distance of approximately 15 kilometers (9 miles) from the proposed quarry site.

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<sup>4</sup> Memorandum to County of Riverside Planning Commission. Paul Weir, Senior Engineer, Sage Environmental Consulting. July 15, 2011.

<sup>5</sup> Sage Environmental Consulting, January 18, 2012.



## **HEALTH IMPACTS MODELING**

PCR has performed an analysis which takes into account the published demographics of the City of Temecula using the U.S. Environmental Protection Agency's Environmental Benefits Mapping and Analysis Program (BENMAP). The USEPA has developed BENMAP to assist large planning agencies such as cities, counties, and states to determine how air pollution concentrations will affect their residents and to assist in developing standards (thresholds). BENMAP contains health studies and equations reviewed and approved by the USEPA. These studies have been peer reviewed by EPA's Clean Air Scientific Advisory Committee (CASAC) and take into account age, race and gender.<sup>6</sup>

Studies considered in the analysis include ones performed by David Abbey which examined the relationship between PM<sub>2.5</sub> and chronic respiratory symptoms of 1,868 Californian residents.<sup>7</sup> In a study by Annette Peters, the relationship between air pollution and heart attacks was analyzed at health centers (hospitals) throughout the United States.<sup>8</sup> These studies take into account the population age, race and gender. A full listing of studies (references) used in this analysis are provided as an attachment to this letter (see Exhibit I).

Population data including age, race and gender was obtained from the US Census Bureau for Year 2000, which was the latest available dataset at the time of analysis. This data was processed using USEPA's PopGrid software to allocate demographic data for health modeling purposes. Population data was then scaled up for Year 2010 demographics based on the available US Census Bureau population data for Year 2010.

Epidemiological studies were then incorporated into BENMAP in the form of health impact functions. These health impact functions are equations which calculate the relationship between the change in pollutant concentration and the change in population health response.<sup>9</sup> Due to the number of epidemiological studies available, a variety of health impact functions are contained within BENMAP to allow the modeler flexibility in adjusting the risk assessment and provide a more conservative analysis. These functions also take into account the uncertainty with calculating health risk, presenting results in a statistical distribution. For purposes of the Liberty Quarry BENMAP health impact assessment, the more conservative health impact functions were selected by PCR and used in the calculations. A listing of health impact functions and references are provided as an attachment to this letter (see Exhibit II).

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<sup>6</sup> USEPA BENMAP Manual Appendices, Appendix K, August 2010.

<sup>7</sup> Chronic Respiratory Symptoms Associated with Estimated Long-Term Ambient Concentrations of Fine Particulates Less than 2.5 Microns in Aerodynamic Diameter and Other Air Pollutants. Abbey et al. (1995)

<sup>8</sup> Increased Particulate Air Pollution and the Triggering of Myocardial Infarction. Peters et al. (2001).

<sup>9</sup> USEPA BENMAP Manual Appendices, Appendix D, August 2010.



## **HEALTH VALUATION ASSESSMENT**

In addition to determining health impacts, the BENMAP model used by PCR also calculates the monetary costs associated with increased pollutant concentrations, such as hospitalizations, chronic illness (bronchitis, asthma, and emphysema), medication and lost wages due to missed work or school days and premature deaths. Similar to health risk functions, health valuation functions take into account numerous scientific studies currently available as well as the uncertainty involved with risk analysis. A listing of health valuation functions are provided as an attachment to this letter (see Exhibit III).

## **RESULTS**

Pollutant concentrations, using the amended emission factors were entered into the BENMAP model. Standard USEPA health impact and health valuation functions were then applied to the pollutant concentration increase while taking into account the actual demographics of the City of Temecula. The health impact endpoints calculated include the increase in heart attacks, asthma exacerbation, bronchitis, emergency room visits, hospital admissions and school and work loss days.<sup>10</sup>

As shown in Table 1 below, the increases in exposure to PM<sub>2.5</sub> levels as a result of emissions from the proposed Liberty Quarry are expected to result in adverse impacts to human health. As mentioned previously, while other criteria pollutants such as PM<sub>10</sub>, NO<sub>2</sub> and ozone have the potential to cause health impacts, health incidence data is limited at this time and was not included in this BENMAP analysis. Results are presented on an annual (1-year) basis as the number of cases which are likely to occur in any given year. The number of cases was then multiplied by the anticipated project life time of 75 years in order to present total health impacts over the duration of the project. This assumes that the demographics and size of the population of Temecula remain relatively unchanged over time.

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<sup>10</sup> Results from preliminary study using project applicant's emissions estimates are provided in Exhibit IV.



**Table 1**

**Increase in Health Impacts due to Liberty Quarry Pollutant Emissions (Number of People Affected)**

[Using 2010 Census Data]

<b>Endpoint Group</b>	<b>Endpoint</b>	<b>Annual Duration (1-year)</b>	<b>Total Project Duration (75-years)</b>
Acute Bronchitis	Acute Bronchitis	1.93	145
Acute Myocardial Infarction	Acute Myocardial Infarction, Nonfatal	0.65	49
Acute Respiratory Symptoms	Minor Restricted Activity Days	605.91	45,443
Asthma Exacerbation	Asthma Exacerbation, Shortness of Breath	128.29	9,622
	Asthma Exacerbation, Wheeze	30.04	2,253
	Asthma Exacerbation, Cough	47.50	3,562
Chronic Bronchitis	Chronic Bronchitis	0.49	37
Emergency Room Visits, Respiratory	Emergency Room Visits, Asthma	0.59	45
Hospital Admissions, Cardiovascular	HA, Congestive Heart Failure	0.04	3
	HA, Dysrhythmia	0.01	1
	HA, Ischemic Heart Disease (less Myocardial Infarctions)	0.02	1
	HA, All Cardiovascular (less Myocardial Infarctions)	0.02	1
Hospital Admissions, Respiratory	HA, Pneumonia	0.05	4
	HA, Chronic Lung Disease	0.02	1
	HA, Chronic Lung Disease (less Asthma)	0.05	4
	HA, Asthma	0.04	3
Lower Respiratory Symptoms	Lower Respiratory Symptoms	24.58	1,843
Premature Mortality	Mortality, All Cause	1.95	146
	Mortality, Ischemic Heart Disease	0.27	20
	Mortality, Lung Cancer	0.06	4
Upper Respiratory Symptoms	Upper Respiratory Symptoms	18.58	1,394
Work Loss Days	Work Loss Days	106.39	7,979



Health impacts shown in Table 1 were then further processed to determine economic impacts due to increased health care costs and lost income from lost work days. Also, as shown in Table 1, exposure to increased PM2.5 concentrations is estimated to result in a premature mortality rate of 1.95 people per year. The Federal and State governments estimate the value of a human life to be approximately \$6.3 million<sup>11</sup>.

As shown in Table 2, pollutant emissions from the Liberty Quarry project would result in a monetary cost to the citizens of Temecula of approximately \$957 million, including premature mortality, over the lifetime of the project.

For comparison purposes, there were a total of 457 deaths in the City of Temecula for 2009<sup>12</sup>. Out of the 457 deaths, approximately 20 were attributed to chronic lower respiratory disease (non-cancer). As shown in Table 1, an additional 1.9 premature deaths from lung disease (non-cancer) will result from exposure to Liberty Quarry's emissions, which represents an increase of approximately 10% due to the Liberty Quarry project.

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<sup>11</sup> Mrozek and Taylor (2002) and Viscusi and Aldy (2003). BENMAP Manual Appendices August 2010.

<sup>12</sup> State of California, Department of Health Services, Death Records. 2010.



**Table 2**  
**Economic Cost of Health Impacts due to Liberty Quarry Pollutant Emissions**  
**[Using 2010 Census Data]**

<b>Endpoint Group</b>	<b>Endpoint</b>	<b>Annual Duration (1-year)</b>	<b>Project Duration (75-years)</b>
Acute Bronchitis		\$1,444	\$54,117
Acute Myocardial Infarction (Heart Attack)		\$388,520	\$14,569,489
Acute Respiratory Symptoms		\$147,908	\$5,546,623
Asthma Exacerbation	Asthma Exacerbation, Cough	\$58,968	\$2,211,280
	Asthma Exacerbation, Shortness of Breath	\$13,808	\$517,814
	Asthma Exacerbation, Wheeze	\$43,664	\$1,637,419
Chronic Bronchitis		\$259,424	\$9,728,380
Emergency Room Visits, Respiratory		\$308	\$11,620
Hospital Admissions, Cardiovascular	HA, All Cardiovascular (less Myocardial Infarctions)	\$3,148	\$118,106
	HA, Congestive Heart Failure	\$1,344	\$50,468
	HA, Dysrhythmia	\$448	\$16,864
	HA, Ischemic Heart Disease (less Myocardial Infarctions)	\$980	\$36,703
Hospital Admissions, Respiratory	HA, Asthma	\$692	\$25,958
	HA, Chronic Lung Disease	\$396	\$14,787
	HA, Chronic Lung Disease (less Asthma)	\$384	\$14,352
	HA, Pneumonia	\$1,616	\$60,552
Lower Respiratory Symptoms		\$9,196	\$344,807
Upper Respiratory Symptoms		\$6,952	\$260,639
Work Loss Days		\$27,788	\$1,041,987
Total (Non-Mortality)		\$483,494	\$36,312,434
Total (Premature Mortality)		<b>\$12,275,950</b>	<b>\$920,696,240</b>
Total			<b>\$957,008,674</b>





Sincerely,  
**PCR SERVICES CORPORATION**

A handwritten signature in cursive script that reads "Heidi Rous".

Heidi Rous,  
Principal/Director Air Quality, Climate, & Acoustics Division

**Attachments**

- Exhibit I – Increase in Health Impacts due to Liberty Quarry
- Exhibit II – BENMAP Valuation Methods
- Exhibit III – List of Health Impact Functions used in BENMAP
- Exhibit IV – Increase in Health Impacts due to Liberty Quarry Using EIR Emissions

# **Liberty Quarry BENMAP Analysis**

**February 2012**

**Exhibits**



## Exhibit I. Increase in Health Impacts due to Liberty Quarry

End Point Group	End Point	1-year (Annual)	75-year (Project Lifetime)	Start Age	End Age	Population
<b>Acute Bronchitis</b>	Acute Bronchitis	1.93	144.66	8	12	7,595
<b>Acute Myocardial Infarction</b>	Acute Myocardial Infarction, Nonfatal	0.65	48.81	18	99	48,016
<b>Acute Respiratory Symptoms</b>	Minor Restricted Activity Days	605.91	45443.09	18	64	43,075
<b>Asthma Exacerbation</b>	Asthma Exacerbation, Cough	128.29	9622.02	6	18	36,530
	Asthma Exacerbation, Shortness of Breath	30.04	2253.18	6	18	18,265
	Asthma Exacerbation, Wheeze	47.50	3562.17	6	18	18,265
	Chronic Bronchitis	0.49	36.62	27	99	40,577
<b>Chronic Bronchitis</b>	Chronic Bronchitis	0.49	36.62	27	99	40,577
<b>Emergency Room Visits, Respiratory</b>	Emergency Room Visits, Asthma	0.59	44.59	0	17	25,338
<b>Hospital Admissions, Cardiovascular</b>	HA, All Cardiovascular (less Myocardial Infarctions)	0.07	5.40	65	99	4,941
	HA, Congestive Heart Failure	0.04	3.27	65	99	4,941
	HA, Dysrhythmia	0.01	1.01	65	99	4,941
	HA, Ischemic Heart Disease (less Myocardial Infarctions)	0.02	1.34	65	99	4,941
	HA, Asthma	0.04	3.02	0	64	68,413
<b>Hospital Admissions, Respiratory</b>	HA, Chronic Lung Disease	0.02	1.19	65	99	4,941
	HA, Chronic Lung Disease (less Asthma)	0.01	1.01	18	64	43,075
	HA, Pneumonia	0.05	3.87	65	99	4,941
	Lower Respiratory Symptoms	24.58	1843.46	7	14	12,135
<b>Mortality</b>	Mortality, All Cause	1.95	146.06	25	99	80,333
	Mortality, Ischemic Heart Disease	0.27	20.46	30	99	38,113
	Mortality, Lung Cancer	0.06	4.16	30	99	38,113
<b>Upper Respiratory Symptoms</b>	Upper Respiratory Symptoms	18.58	1393.64	9	11	4,540
<b>Work Loss Days</b>	Work Loss Days	106.39	7978.95	18	64	43,075

Source: BenMAP Environmental Benefits Mapping and Analysis Program User's Manual, August 2010



## Exhibit II. BENMAP Valuation Methods

Endpoint Group	Endpoint	ValuationMethod
Acute Bronchitis		WTP: 28 symptom-days, Dickie and Ulery (2002).   0-17
Acute Myocardial Infarction		COI: 10 yrs med, 5 yrs wages, 3% DR, Eisenstein (2001)   0-24 COI: 10 yrs med, 5 yrs wages, 3% DR, Eisenstein (2001)   25-44 COI: 10 yrs med, 5 yrs wages, 3% DR, Eisenstein (2001)   45-54 COI: 10 yrs med, 5 yrs wages, 3% DR, Eisenstein (2001)   55-64
Acute Respiratory Symptoms		WTP: 1 day illness, CV studies   18-65 WTP: 3 symptoms 1 day, Dickie and Ulery (2002).   18-99
Asthma Exacerbation	Asthma Exacerbation, Cough	WTP: 1 symptom-day, Dickie and Ulery (2002)   0-17
	Asthma Exacerbation, Shortness of Breath	WTP: 1 symptom-day, Dickie and Ulery (2002)   18-99
	Asthma Exacerbation, Wheeze	WTP: 1 symptom-day, Dickie and Ulery (2002)   0-17 WTP: 1 symptom-day, Dickie and Ulery (2002)   18-99 WTP: 1 symptom-day, Dickie and Ulery (2002)   18-99 WTP: 1 symptom-day, Dickie and Ulery (2002)   18-99
Chronic Bronchitis		COI: med costs + wage loss, 3% DR   27-44 COI: med costs + wage loss, 3% DR   45-64 COI: med costs + wage loss, 3% DR   65-99 COI: Stanford et al. (1999)   0-99
Emergency Room Visits, Respiratory		COI: med costs + wage loss   0-99
Hospital Admissions, Cardiovascular	HA, All Cardiovascular (less Myocardial Infarctions)	COI: med costs + wage loss   65-99
	HA, Congestive Heart Failure	COI: med costs + wage loss   0-99
	HA, Dysrhythmia	COI: med costs + wage loss   65-99
	HA, Ischemic Heart Disease (less Myocardial Infarctions)	COI: med costs + wage loss   0-99
Hospital Admissions, Respiratory	HA, Asthma	COI: med costs + wage loss   0-99
	HA, Chronic Lung Disease	COI: med costs + wage loss   0-99
	HA, Chronic Lung Disease (less Asthma)	COI: med costs + wage loss   0-99
	HA, Pneumonia	COI: med costs + wage loss   0-99
Lower Respiratory Symptoms		WTP: 2 symptoms 1 day, Dickie and Ulery (2002)   0-17
Mortality	Mortality, All Cause	VSL, based on 26 value-of-life studies.   0-99
	Mortality, Ischemic Heart Disease	VSL, based on 26 value-of-life studies.   0-99
	Mortality, Lung Cancer	VSL, based on 26 value-of-life studies.   0-99
Upper Respiratory Symptoms		WTP: 2 symptoms 1 day, Dickie and Ulery (2002)   0-17
Work Loss Days		Median daily wage, county-specific   18-65

Source: BenMAP Environmental Benefits Mapping and Analysis Program User's Manual, August 2010



**Exhibit III. List of Health Impact Functions used in BENMAP**

Endpoint Group	Endpoint	Reference
Acute Bronchitis	Acute Bronchitis	Dockery, D.W., J. Cunningham, A.I. Damokosh, L.M. Neas, J.D. Spengler, P. Koutrakis, J.H. Ware, M. Raizenne and F.E. Speizer. 1996. Health Effects of Acid Aerosols On North American Children - Respiratory Symptoms. Environmental Health Perspectives. Vol.
Acute Myocardial Infarction	Acute Myocardial Infarction, Nonfatal	Peters, A., D.W. Dockery, J.E. Muller and M.A. Mittleman. 2001. Increased particulate air pollution and the triggering of myocardial infarction. Circulation. Vol. 103 (23): 2810-5.
Acute Respiratory Symptoms	Minor Restricted Activity Days	Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Asthma Exacerbation	Asthma Exacerbation, Cough	Ostro, B., M. Lipsett, J. Mann, H. Braxton-Owens and M. White. 2001. Air pollution and exacerbation of asthma in African-American children in Los Angeles. Epidemiology. Vol. 12 (2): 200-8.
		Vedal, S., et al., Acute effects of ambient inhalable particles in asthmatic and nonasthmatic children. American Journal of Respiratory and Critical Care Medicine, 1998. 157(4): p. 1034-1043.
	Asthma Exacerbation, Shortness of Breath	Ostro, B., M. Lipsett, J. Mann, H. Braxton-Owens and M. White. 2001. Air pollution and exacerbation of asthma in African-American children in Los Angeles. Epidemiology. Vol. 12 (2): 200-8.
	Asthma Exacerbation, Wheeze	Ostro, B., M. Lipsett, J. Mann, H. Braxton-Owens and M. White. 2001. Air pollution and exacerbation of asthma in African-American children in Los Angeles. Epidemiology. Vol. 12 (2): 200-8.
Chronic Bronchitis	Chronic Bronchitis	Abbey, D.E., B.E. Ostro, F. Petersen and R.J. Burchette. 1995. Chronic Respiratory Symptoms Associated with Estimated Long-Term Ambient Concentrations of Fine Particulates Less Than 2.5 Microns in Aerodynamic Diameter (PM2.5) and Other Air Pollutants. J E
Emergency Room Visits, Respiratory	Emergency Room Visits, Asthma	Norris, G., et al. An association between fine particles and asthma emergency department visits for children in Seattle. Environ Health Perspect, 1999. 107(6): p. 489-93.
Hospital Admissions, Cardiovascular	HA, All Cardiovascular (less Myocardial Infarctions)	Moolgavkar, S.H. Air Pollution and Daily Deaths and Hospital Admissions in Los Angeles and Cook Counties. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 183-198.
	HA, Congestive Heart Failure	Ito, K. Associations of Particulate Matter Components with Daily Mortality and Morbidity in Detroit, Michigan. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 143-156.
	HA, Dysrhythmia	Ito, K. Associations of Particulate Matter Components with Daily Mortality and Morbidity in Detroit, Michigan. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 143-156.
	HA, Ischemic Heart Disease (less Myocardial Infarctions)	Ito, K. Associations of Particulate Matter Components with Daily Mortality and Morbidity in Detroit, Michigan. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 143-156.
Hospital Admissions, Respiratory	HA, Asthma	Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
	HA, Chronic Lung Disease	Moolgavkar, S.H. Air Pollution and Daily Deaths and Hospital Admissions in Los Angeles and Cook Counties. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 183-198.
	HA, Chronic Lung Disease (less Asthma)	Moolgavkar, S.H. Air Pollution and Hospital Admissions for Chronic Obstructive Pulmonary Disease in Three Metropolitan Areas in the United States. Inhalation Toxicology, 2000. 12(Supplement 4): p. 75-90.
	HA, Pneumonia	Ito, K. Associations of Particulate Matter Components with Daily Mortality and Morbidity in Detroit, Michigan. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 143-156.
Lower Respiratory Symptoms	Lower Respiratory Symptoms	Schwartz, J. and L.M. Neas. 2000. Fine particles are more strongly associated than coarse particles with acute respiratory health effects in schoolchildren. Epidemiology. Vol. 11 (1): 6-10.
Mortality	Mortality, All Cause	Laden, F., J. Schwartz, F. E. Speizer and D. W. Dockery. 2006. Reduction in Fine Particulate Air Pollution and Mortality: Extended follow-up of the Harvard Six Cities Study. Am J Respir Crit Care Med.
		(blank)
	Mortality, Ischemic Heart Disease	Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
	Mortality, Lung Cancer	Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Upper Respiratory Symptoms	Upper Respiratory Symptoms	Pope, C.A., et al. Respiratory Health and Pm10 Pollution - a Daily Time Series Analysis. American Review of Respiratory Disease, 1991. 144(3): p. 668-674.
Work Loss Days	Work Loss Days	Ostro, B.D. Air Pollution and Morbidity Revisited: A Specification Test. Journal of Environmental Economics and Management, 1987. 14: p. 87-98.

Source: BenMAP Environmental Benefits Mapping and Analysis Program User's Manual, August 2010





### Exhibit IV - Health Impacts due to Liberty Quarry (Original EIR Emissions)

Endpoint Group	Endpoint	Exposure Duration	
		Annual (1-year)	Project Lifetime (75-year)
Acute Bronchitis	Acute Bronchitis	1.4296	107
Acute Myocardial Infarction	Acute Myocardial Infarction, Nonfatal	0.4838	36
Acute Respiratory Symptoms	Minor Restricted Activity Days	449.91	33,743
Asthma Exacerbation	Asthma Exacerbation, Cough	94.687	7,102
	Asthma Exacerbation, Shortness of Breath	22.1686	1,663
	Asthma Exacerbation, Wheeze	35.0448	2,628
Chronic Bronchitis	Chronic Bronchitis	0.3628	27
Emergency Room Visits, Respiratory	Emergency Room Visits, Asthma	0.4414	33
Hospital Admissions, Cardiovascular	HA, All Cardiovascular (less Myocardial Infarctions)	0.0534	4
	HA, Congestive Heart Failure	0.0316	2
	HA, Dysrhythmia	0.01	1
	HA, Ischemic Heart Disease (less Myocardial Infarctions)	0.0118	1
Hospital Admissions, Respiratory	HA, Asthma	0.0288	2
	HA, Chronic Lung Disease	0.011	1
	HA, Chronic Lung Disease (less Asthma)	0.0094	1
	HA, Pneumonia	0.0382	3
Lower Respiratory Symptoms	Lower Respiratory Symptoms	18.1816	1,364
Mortality	Mortality, All Cause	0.9992	75
	Mortality, Ischemic Heart Disease	0.2376	18
	Mortality, Lung Cancer	0.0484	4
Upper Respiratory Symptoms	Upper Respiratory Symptoms	13.722	1,029
Work Loss Days	Work Loss Days	79.0118	5,926



### Exhibit IV - Costs related to Health Impacts due to Liberty Quarry (Original EIR Emissions)

Endpoint Group	Endpoint	Annual (1-year)	Project Lifetime (75-year)
Acute Bronchitis		\$535	\$40,106
Acute Myocardial Infarction		\$144,457	\$10,834,279
Acute Respiratory Symptoms		\$43,989	\$3,299,174
Asthma Exacerbation	Asthma Exacerbation, Cough	\$21,771	\$1,632,809
	Asthma Exacerbation, Shortness of Breath	\$5,097	\$382,282
	Asthma Exacerbation, Wheeze	\$8,058	\$604,341
Chronic Bronchitis		\$96,295	\$7,222,142
Emergency Room Visits, Respiratory		\$115	\$8,631
Hospital Admissions, Cardiovascular	HA, All Cardiovascular (less Myocardial Infarctions)	\$1,179	\$88,447
	HA, Congestive Heart Failure	\$504	\$37,798
	HA, Dysrhythmia	\$168	\$12,633
	HA, Ischemic Heart Disease (less Myocardial Infarctions)	\$367	\$27,488
Hospital Admissions, Respiratory	HA, Asthma	\$257	\$19,245
	HA, Chronic Lung Disease	\$148	\$11,074
	HA, Chronic Lung Disease (less Asthma)	\$141	\$10,595
	HA, Pneumonia	\$605	\$45,352
Lower Respiratory Symptoms		\$283	\$21,236
Mortality	Mortality, All Cause	\$10,787,013	\$809,026,002
	Mortality, Ischemic Heart Disease	\$1,509,857	\$113,239,291
	Mortality, Lung Cancer	\$316,259	\$23,719,420
Upper Respiratory Symptoms		\$2,567	\$192,537
Work Loss Days		\$10,318	\$773,881
<b>Total</b>		<b>\$12,949,983</b>	<b>\$834,290,049</b>